Space Weather Technical Forecast

Issued on Thursday, 16 November 2023 at 13:06 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Possible Earth-bound CME due in new UTC working week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has remained Low over the past 24 hours, with a relatively subdued X-ray trace at GOES16 peaking with an isolated C7.7 at 15/1212UTC from off-going Ex-AR3485 in the southwest. There are now up to three sunspot regions on the visible disc, as although AR3488 faded to plage in the northeast, it was replaced by a possible second unipolar region here nearer the meridian in the current UTC morning. Nominally the most complex of the (other) two numbered regions is AR3486, which has undergone some consolidation in the past 12 hours or so, while AR3487 has shown some proliferation of spots, all while remaining small and relatively magnetically simple.

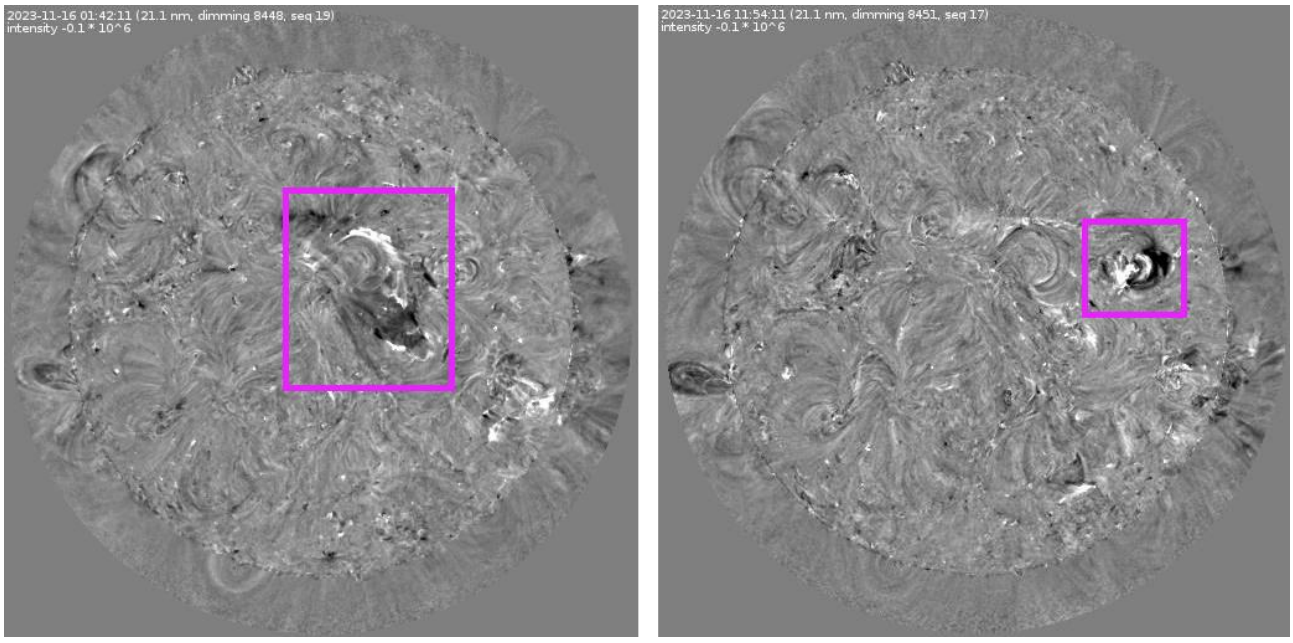

Figure 0: Two events potentially of note in the period in time-integrated extreme UV (AIA211 – processing courtesy of SIDC ROB). Firstly the 16/0100UTC filament eruption (left) and secondly a coronal dimming in the northwest around 16/1130UTC (right).

There were a number of Coronal Mass Ejections (CMEs) visible on coronagraph imagery in the past 24 hours, and unpicking them has been a major task of the current UTC morning. Of all these events, potentially most relevantly a filament channel-like signature was seen on the northwest disc near N20W020 on AIA304 imagery after 16/0100UTC. This event unfortunately coincided with a gap in in ground-based observatory H-Alpha coverage, however the lead-up was captured as an emerging and darkening filament on Udaipur - a footprint that has since vanished. This feature has been analysed and carries a chance of affecting Earth around the turn of the UTC day Monday 20

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into Tuesday 21 November, although with significant error bars of around +/-12 proffered by the MOSWOC Enlil ensemble. A second candidate for a CME of note was then observed as a dimming in the northwest quadrant at 16/1130UTC. Imagery for this event is awaited.

The other coronagraph-polluting events of the period were: firstly, a far-sided high latitude event in the northeast around 15/1300UTC; secondly, a slower prominence leaving the southwest disc around 15/1500UTC; and thirdly, a low latitude far-sided CME leaving the disc starting 16/0400UTC. None of these are currently thought likely to affect the forecast.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, were initially at Background, but showed a slight overall rising trend into Slightly Elevated levels as the period progressed. There was no clear 'seam' between any slow and fast regimes, however there is a faint possibility that a hesitant connection to CH70/- is establishing, with a hitherto mainly positive phi angle perhaps seeing lengthening negative periods (towards the Sun) from around 16/0600UTC, although this is far from conclusive attribution.

The solar wind speed rose from 375-400km/s to reach 425-450 by the end of the period. The solar wind density trend was unremarkable - complicated by the switch in measuring satellites but generally staying within typical single figures ppcc throughout. The IMF showed a level trend at or below 6nT, while the north-south component ranged between -6 and +5nT over the same interval.

The net result of the above solar wind measures was for provisionally Quiet to Unsettled geomagnetic activity, with Kp peaking at 3+ in the 18-21UTC interval.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux was at Normal Background. The associated 24-hour fluence was below the Active (1e8 integrated pfu) threshold. The fluence observation at 16/0001UTC was 2.98e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Low, but with a daily Slight Chance of rising to Moderate, more so later in the four-day period given the prospect of eastern limb arrivals.

Solar Wind / Geomagnetic Activity: The 16/0100UTC possible filament-related CME may affect Earth beyond the scope of this forecast period, i.e. around the turn of the UTC day Monday 20 into Tuesday 21 November, with +/-12 hour error bars. A second possible CME candidate from 16/1130UTC is awaiting imagery. No other CMEs were noted.

The coronal hole based forecast is relatively low confidence but low impact, with a weak enhancement from CH70/- possible on day 1 (Thursday 16 November), easing by the coming UTC weekend.

There is a Slight Chance of isolated Active periods in the first 24 hours of the forecast, else Quiet activity should predominate. There is perhaps a Slight Chance of G1 into the new working week as a result of the 16/0100UTC CME, with further analyses likely to distil this forecast further.

Energetic Particles / Solar Radiation: GOES16 High energy proton flux is expected to remain at Background. GOES16 High energy electron flux is likely to rise through the period as any elevated electron populations at lower orbits relax back towards GEO. This is low confidence however, especially with the potential for further weak enhancements to the solar wind on day 1 (Thursday 16 November). The associated electron fluence is likely to remain below the Active threshold (1e8 integrated pfu) but confidence lower by days 3-4 (UTC weekend).

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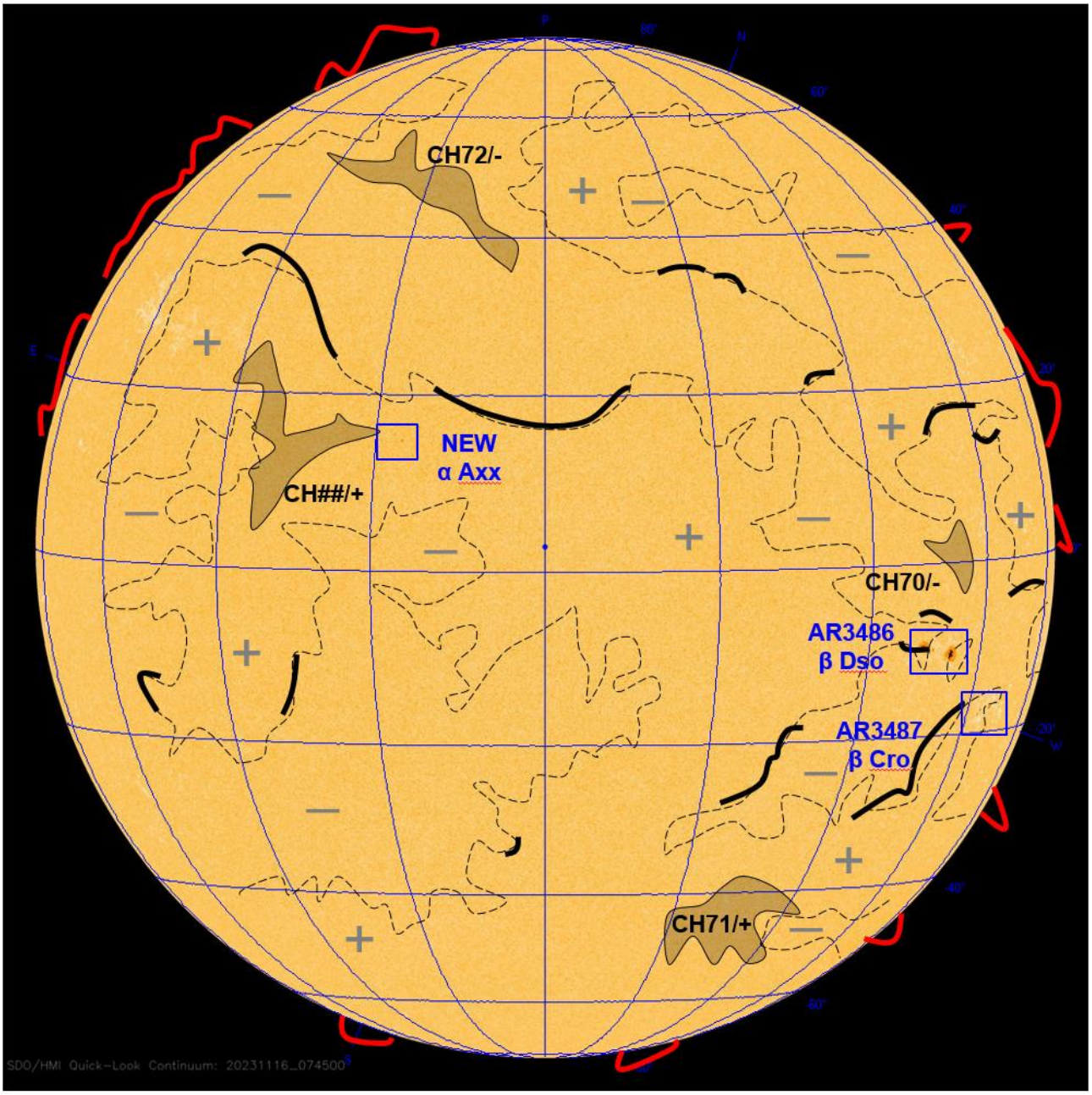
Figure 1. Solar Analysis Valid 16/0745UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The filament channel signature from near N20W020 16/0100UTC has been analysed and the latest MOSWOC Enlil model (badged 0800UTC) and tied ensemble suggest this may cross 1AU and affect Earth around the turn of the UTC day Monday 20 into Tuesday 21 November. This feature has significant error bars associated with it given the poor triangulation offered by STEREO A compared with L1, however a slower, wider solution is perhaps preferred given the lack of an associated X-ray flare and the subtlety of the event itself. Error bars of +/-12 hours are offered by the ensemble and are accepted as good guidance. As noted in the Solar Activity section, there is a possibility of a second CME candidate emanating from the northwest disc 16/1130UTC, however this will be assessed in due course. Neither CME currently features in the probability tables owing to 1) a slow transit of the 16/0100UTC CME (putting arrival beyond the four days); and 2) a lack of coronagraph imagery for the 16/1130UTC event.

CH70/- is otherwise the main feature in the forecast. MOSWOC Enlil indicates a weak enhancement into the current UTC day, and it is still very possible that delayed onset may occur on day 1 (Thursday 16 November), perhaps increasing winds to around 450km/s, however this is low confidence. A return to mainly background winds is expected by the UTC weekend.

There is a Slight Chance of isolated Active periods in the first 24 hours of the forecast, else Quiet activity should predominate. Beyond the four-day forecast period, there is perhaps a Slight Chance of G1 into the new working week as a result of the 16/0100UTC CME, with further analyses likely to distil this forecast further.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/1608	Partial	Poss filament	Near N20W020	279km/s	Around turn of UTC day 20 into 21 November +/-12 hours	Low confidence in speed and cone, but likely to lie on Sun-Earth line.

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Figure 2: Coronagraph difference imagery fits for the 16/0100UTC filament CME. The cone and speed are particularly low confidence, however something on the lower end of possible speeds is considered more physical given the near complete lack of any flare and the languid extreme UV appearance. Note the polluting ejecta attributed to other CMEs outside the suggested main envelope of the 16/0100UTC event.

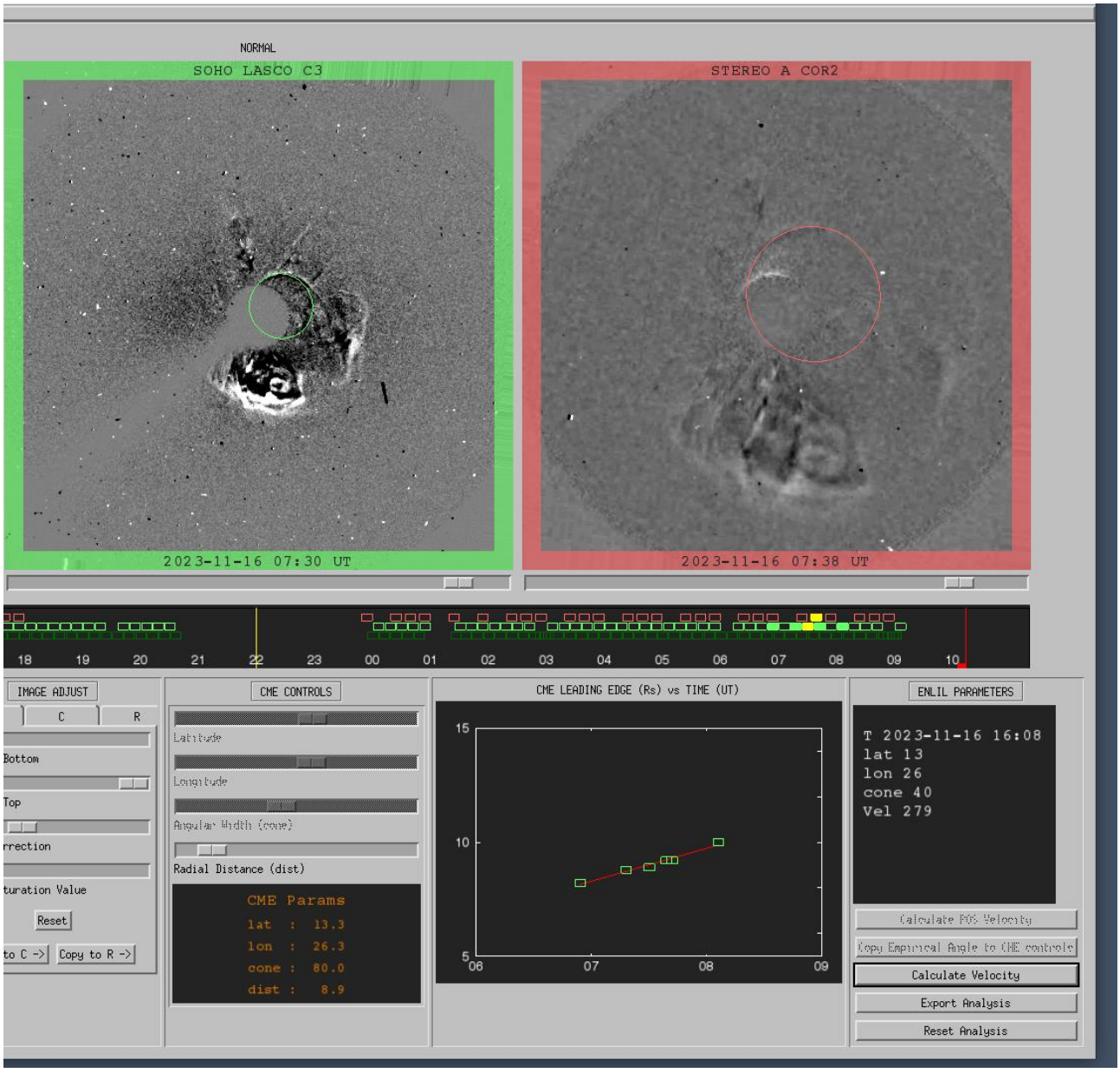

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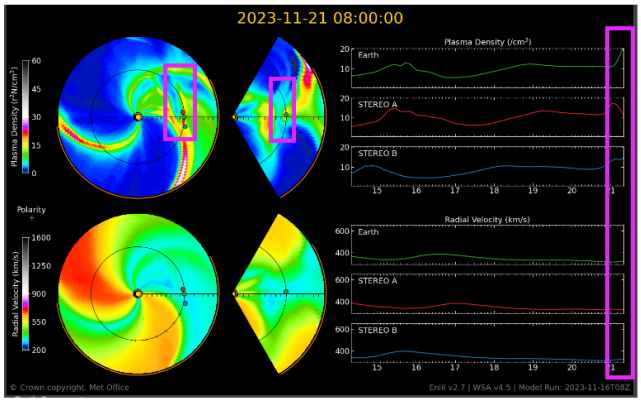
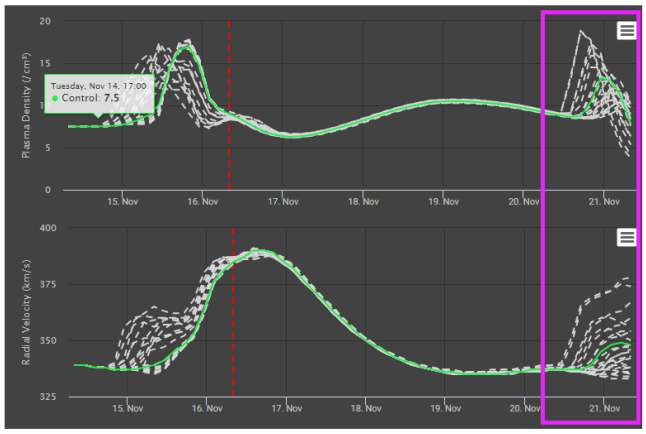
Figure 3: Latest MOSWOC Enlil run and ensemble, showing both the missed 10 November CME early in the run, but now also the 16/0100UTC filament at the very end, with a significant spread in solutions. Further fits will be conducted to firm up any arising geomagnetic activity, although the uncertainty is on 'arrival time' rather than 'arrival' – i.e. it should intersect the Sun-Earth line.





Radio Blackouts - X-Ray Flares:

Solar Activity is currently Low, with a very sparsely populated facing side of the Sun in terms of sunspots. This is true to the extent that the brightest portions of the current 'disc' are in fact the fading southwest limb as Ex-AR3485 departs, but now increasingly also the southeastern limb, perhaps hinting that any arriving region here is likely to take up the mantle of becoming the most complex and most liable to flares.

Until any arrivals manifest, and with the gradual departures of the numbered current southwestern spots later in the UTC weekend not expected to significantly alter the risks, the most notable activity on the disc is perhaps most likely to come from any filament eruptions, with some large filaments extending across the northern disc and also the southwestern disc. While these appear stable, some long-period X-ray activity would be possible were they to erupt.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	10	10	15	20
Very Active	R3 to R5 X Class	No	1	1	1	1

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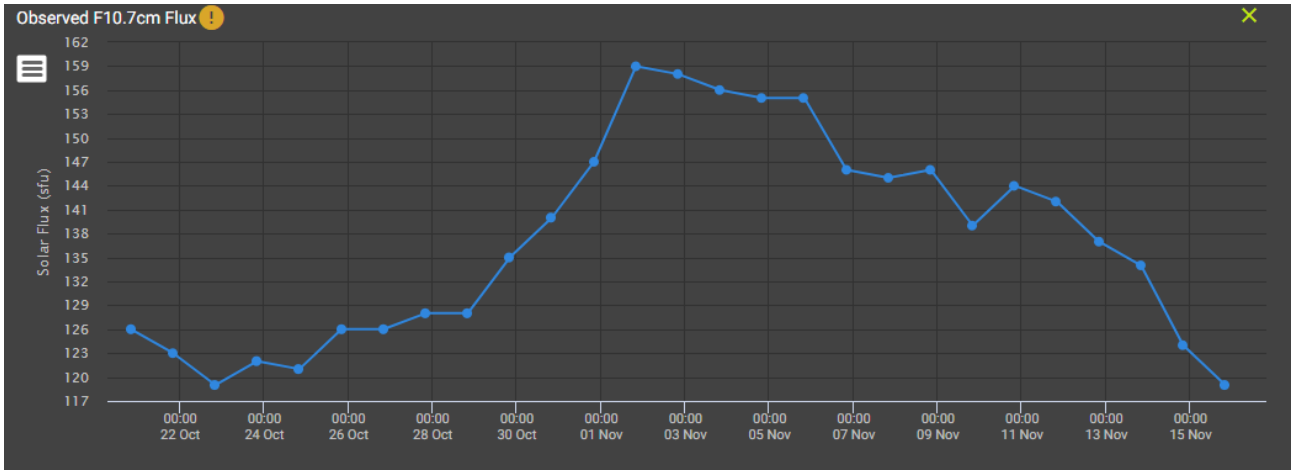
Figure 4: Past 27 days in Penticton 10.7cm flux, showing a current nadir reflective of the dearth of front-sided groups.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater then 10Mev) proton flux observed by GOES16 is currently at Background levels and expected to persist at this level. The main risk of any increase to the proton flux will be from any notable filament eruptions, however these are currently considered unlikely to reach the S1 level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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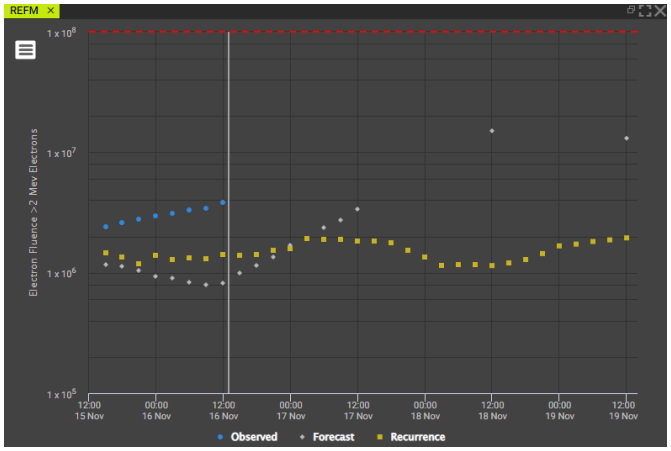
High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GOES16 has persisted at Normal Background, with recent solar wind enhancements increasingly likely to have only a minimal impact at GEO. The postulated fast wind connection on day 1 (Thursday 16 November) is unlikely to significantly increase electron counts, even at its peak, but there is an increasing chance of at least Moderate flux being realised as a result, most likely over the UTC weekend.

The associated 24-hour electron flux is expected to remain below the Active (1e8 integrated pfu) level, but with decreasing confidence over the UTC weekend. This is supported by REFM, which shows a very slight rise in forecast and persistence trends and as a result is considered to be giving good guidance for a least the next 24 hours.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Latest MOSWOC REFM, showing fluence observations, forecast and persistence trends.



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